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Association between resuscitationtime intervalat the scene andneurological outcomeafter out-of-hospital cardiac arrest in two Asian cities

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ABSTRACT

Background: It is unclear whether the scene time interval (STI) for cardiopulmonary resuscitation (CPR) is associated with outcomes of out-of-hospital cardiac arrest (OHCA) or not.

Methods: A retrospective analysis based on two large population-based cohortswas performed forwitnessed adult OHCA with presumed cardiac etiology from Seoul (2008-2010) and Osaka (2007-2009). The STI defined as time from wheel arrival at the scene to departure to hospital was categorized by short (less than 8 minutes), intermediate (8 to less than 16 minute), and long (16 min or longer) STI on the basis of sensitivity analysis. Primary outcome was good neurological outcome (cerebral performance category 1 or 2).Adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated to determine the association between STIs and outcomes comparing with the short STI group adjusting for potential risk factorsand interaction products.

Results: Total 7,757 patients;3,594 from Seoul and 4,163 from Osaka were finally analyzed. There were significant differences among STI groups for most potential risk variables. Survival to admission was higher in the intermediate STI group (35.7%) than in the short (31.8%) or long STI group (32.6%), respectively (p=0.004). Survival to discharge was not different among groups (13.7%, 13.1%, 11.5%), respectively (p=0.094).The intermediate STI

group had a significantly better neurological outcome compared with the short STI group (7.7% vs. 4.6%; AOR, 1.32; 95% CI, 1.03-1.71), while the long STI (6.6%) did not.

Conclusion: Data from two metropolitan cities demonstrateda positiveassociation between intermediate STI from 8 to 16 minutes and good neurological outcome after OHCA.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a major publichealth problem around the world.[1]Emergency medical service (EMS) factors have been known to be one of the major determinants for outcomes after OHCA as well as bystander performance and hospital post-resuscitation care.[2-5]Among EMS factors, response time interval (RTI) from call to arrival at the scene isknown to be associated with outcomes,whereas the effect ofscene time interval (STI) for cardiopulmonary resuscitation (CPR),from ambulance arrival at the scene to departure to hospital, isunclear.

Although some EMS systems like Osaka allow longer STI than others, in many Asian countries including Korea and Japan, EMS protocols do not basically allow them to stop CPR at the scene unless there is a return of spontaneous circulation (ROSC) and require scoop and run to the hospital emergency department (ED) while giving CPR during transport (Scoop and Run model).[6-9]In addition, advanced life support (ALS) procedures provided by EMS personnel on the scene are very limited. These protocols are very different from those in North America, Europe, and Australia,where EMS providers continue to perform CPR until getting the ROSC or stopping CPR for death declaration on the scene (Stayand Treat model).[10,11]The 2010 American Heart Association guideline has no comments regarding how long the EMS personnel stay at the scene to provide CPR or how many CPR cycles areessential for scene CPR.[10,11]

We hypothesizedthat the STI staying at the sceneto provide CPR is a key determinant for outcomes in OHCA in EMS systems because it is a very important treatment time interval after cardiac arrests.During this period, EMS personnel would provide varioustreatments at the scene including CPR, defibrillation, airway management, and fluid resuscitation.[12]The longer STI for CPR has a benefit of providing a likelihood of more stable and higher-quality CPR, while the shorter STI has a benefit of faster, more comprehensive and earlier advance care in ED. In contrast, there would be a disadvantage of delayed advance care by ED in the longer STI protocol,butmore unstable CPR during ambulance transport in the shorter STIsystem. Bycomparing the outcomesaccording to STI for CPR, we can develop amore effective scene protocol for the EMS system.Thepresent study aimed to determine the association between STI and neurological outcomeafter OHCA using two large population-based cohorts covering two metropolitan cities in Asia.

2. Methods

2.1.Study method and materials

The Seoul-Osaka Resuscitation Study (SORS) group is a volunteer-based collaborating study group between two communities' research scientists in Seoul Korea and Osaka Japan, respectively. The study was approved by the institutional review boards of the study hospitals(Seoul National University and Osaka University).

2.2. Study setting

This study was done in two metropolitan cities, Seoulin Korea and Osaka in Japan. The population size was 9.9 million in Seoul (2009) and 8.8 million in Osaka (2010). Population density was 16,356 per km^2 in Seoul and 4,642 per km^2 in Osaka.

The EMS level is intermediate in both areas where the highest-qualifiedemergency medical technicians can give CPR with automatic external defibrillation (AED), perform advanced airway management, and insert intravenous fluid. EMS providers should not stop CPR unless there is a ROSCon the scene. In Seoul, EMTs are encouraged to “scoop and run” to a hospital emergency departmentwhile giving CPR during ambulance transport as soon as possible after giving one cycle of CPR followed by automatic external defibrillation.More than one cycle of CPR and rhythm analysis with/without shock at the scene, intravenous fluid resuscitation, advanced airway management, and drug infusionare not obligatory but optional in this system. EMS providers canchoose their option according to families’ attitude, patient’s condition, self-confidence level for procedures, and expected transport time to ED. They give continuous CPR during ambulance transport.[13]In Osaka, EMTs are usually encouraged tostay around 10 minutes for interventionsincludingthree to four cycles of CPRwith rhythm analysis every 2 minutes, intravenous fluid resuscitation, advanced airway management, and drug infusion.[14] The emergency life-saving technician (ELST) systems in Osaka were started in 1991;specially-trained ELSTs began to use endotracheal intubation in July 2004, and administered adrenaline since July 2006, while the first-degree EMTs in Seoul can opt for the airway managementfrom among Bag-Valve-Mask ventilation, supraglottic airway, and endotracheal intubation according to their preference. A system quality program was initiated in 1998 in the Osaka through Osaka Utstein Project, while the quality control was rare in Seoul until 2011.[5,8,13-16]

The number of ambulance crew per ambulance isthree in both areas;first-degree EMT (intermediate EMT), second-degree EMT (basic EMT), and driver (first responder level) in Seoul, andthree EMSs with at least one ELST (intermediate EMT)in Osaka. The first-degree EMTs in Seoul are usually graduatesof EMT colleges with three- to four-year courses. In Osaka, there are two processes to qualify as an ELST.[14]The first is through the specialized education system in the fire department. The second way is through the education system in the EMT school and college.

There are 114 ambulance unitsavailable for service coverage of 24-hour/ 365 days in Seoul (2010) and 212 ambulance units in Osaka (2009). Hospital EDs for OHCA are categorized intofourlevels in Seoul includingone regional ED (level 1) and 27 local EDs (level 2). Level 1 and 2 EDs are covered by emergency physicians for 24/365 services and received approximately 80% of OHCA.In Osaka, there are 13 critical care medical centers (level 1) and 258 emergency centers (level 2). Level 1 ED can be used for very high criticality such as OHCA, severe trauma, and respiratory failure, and has received approximately 20% of OHCA, every yearwhile level 2 EDs are used for moderate emergency conditions. The classification of ED levels differ by areas. The level 1 and some of level 2 hospitals in both cities usually provide therapeutic hypothermia and cardiac interventions (percutaneous coronary intervention and coronary bypass surgery).

2.3. Study population

Study population was EMS-treated and bystander-witnessed adult (18 years and older) OHCA with presumed cardiac etiology. The study period was from Jan. 2008 to Dec. 2010 for Seoul and from Jan. 2007 to Dec. 2009 for Osaka. OHCA with non-cardiac etiology, not treated cases, and patients less than 18 years were excluded.

2.4. Data sources

Data were collected from the EMS run sheet in Osaka and from the EMS run sheet and hospital medical record review in Seoul. Utstein factors including age, sex, location(public orprivate), and bystander CPR (yes or no), prehospital defibrillation, and primary ECG (ventricular fibrillation / tachycardia or not) were collected. Both data used the same definition according to the Utstein data report form. In Osaka, first documented ECG was examined at the scene, while that in Seoul was examined for some patients at the scene and for most patients at the ED.Public accessdefibrillation was performed for several cases in Osaka while there was no case in Seoul becausethe PAD program started in 2010 in that city. Dataset details were reported in previous studies.[5,8,13-16]

The elapsed time intervals such as response time interval (RTI) from call to wheel arrival at scene, scene time interval (STI) from wheel arrival to departure to ED, andtransportation time interval (TTI) from departure at thesceneto arrival at EDwere standardized and measured in both areas.

2.5. Outcome measure

Primary outcome was good neurological outcome at hospital discharge (Seoul) and atonemonth after event (Osaka), which was defined as cerebral performance category 1 or2. The secondary outcome was survival to discharge (Seoul) or onemonth survival (Osaka), and survival to admission.

Outcomes were collected by EMS providers onemonth after transporting patients to EDs in Osaka via telephone or fax contact to hospital. In Seoul, hospital medical record review was performed after hospital discharge. Medical record review was done by medical record experts employed at Korean Centers for Disease Controls and Prevention.Information on neurological outcome was unavailable for six patients (0.2%) in Seoul and five cases (0.1%) in Osaka.

2.6. Main exposure variables

We categorized the STI according to the sensitivity analysis. Restrictive cubic spline logistic analysis with five nodes was used to determine the cut-off value for categorizing STI subgroups. The analysis used two variables (scene time intervals and good neurological outcome) and unadjusted odds ratios (ORs) with 95% confidence intervals (95% CIs) of STI group tocalculate according to STIs (unit= one min.)on the outcome. We decided STIs responding to the mean probability of survival as the two cut-off values in the curve. The STI was categorized with short STI, intermediate STI, and long STI using two cut-values.

2.7. Statistical analysis

Demographic findings were described according to the two communities. Potential risk factors and outcomes were compared by STI groups.Continuous variables are described by mean withstandard deviation or median with the interquartile range. Categorical variables are measured by number and percent. Descriptive analysis used the Student *t*-test for continuous variables and chi-square test for categorical variables. ANOVA test was used for the comparison among three STI groups.

Adjusted odds ratios and 95% confidence intervalson outcomes were calculated for each

STI group (reference=short STI) using multivariable logistic regression models. Potential risk factors were age, sex, RTI, TTI, place, bystander CPR, primary ECG, and prehospital defibrillation by layperson or EMS providers. These factors have been known to be associated with outcomes in many previous studies. Study city (Seoul and Osaka) would also be a potential risk although we adjusted for many relevant variables in the model. First, we tested interactions between STI and city on the outcomes because thetwo cities significantly showed the different STI distribution. After testing forinteractions, the city level was also incorporated into the final model because there was no significant interaction.

We assessed the interaction between main exposure (STI) and other potential risk factors for main outcome using the chunk test and followed by backward elimination process for full model which included main exposure, potential risks, and all potential interaction products. We dropped out the interaction products according to the order of size of p-value>0.01 using the analysis of maximum likelihood estimates in the model. The interaction term with the biggest p-value was removed from the model and also assessed the remaining interaction terms. This backward elimination processes were repeated to get final model where all potential confounders and significant interactions remained. If there was any significant interaction with p-value <0.01 between main exposure and other potential risks, we calculate adjusted ORs and 95% confidence intervals to estimate the summation of effect of the STI plus effect modifiers on outcomes in each subgroup.

3. Results

Total 3,594 patients were enrolled from Seoul among 10,122 from 2008 to 2010 excluding EMS-not treated (*n*=1,511), less than 18 years (*n*=232), unwitnessed(*n*=4,279), and non-cardiac etiology (*n*=506). A total of 4,163 patients among 21,032 patients from 2007 to 2009 in Osaka were included, excluding no-treated EMS (*n*=1,645), less than 18 years old (*n*=335), not bystander-witnessed (*n*=12,455), and non-cardiac etiology (*n*=2,434) (Fig.1).Of these, the proportion of female, elderly older than 70 years, public sites, bystander CPR performed, bystander and EMS defibrillation, ventricular fibrillation/tachycardia was significantly higher in Osaka than Seoul. Pre-hospitalROSC, survival to admission and survival to discharge (or one-month survival), and good neurological outcome weresignificantly better in Osaka than Seoul (Table 1).

We found the three peaks in the probability of survival in the restricted cubic spline curve; the first peak wasdownward around 5 min between 0 to 7 min, when the portion of intact neurological outcome was the lowest, the second upward around 12min between 8 to 15 min, when intact neurological outcome was highest, and the third downward around 18 min,in the interval of more than 16 min, when the outcomes were poor again. We selected two cut-off values for categorizing the STI using 8 min and 16 min,respectively, responding to average value of good neurological outcome (6.4%) (Fig. 2).The STI was categorized with three groups; short STI for 0 to 7 min, intermediate STI for 8 to 15 min, long STI for 16 min, and longer.

There were significant differences among STI groups for city, gender, age group, place of arrest, bystander CPR, bystander defibrillation, defibrillation by EMS provider, primary ECG rhythms, RTI, but not TTI(Table 2). Survival to admissionor to discharge and good neurological outcome was highest in the intermediate STI group (35.7%, 13.7%, 7.7%) compared to the short(31.8%, 13.1%, 4.6%)or the long STI group (32.6%, 11.5%, 6.6%), respectively (Table 3). The proportion of good neurological outcome in Seoul was the highest in the intermediate STI group (3.6%) while that in Osaka in the short STI group (11.4%). The proportion of prehospital ROSC in Seoul was the highest in intermediate STI group (4.2%) while that in Osaka in long STI group (17.6%). The outcomes by the STI groups were significantly different by city level. There was no significant interaction ($p<0.01$) between city level and STI group for prehospital ROSC ($p=0.711$), survival to admission ($p=0.724$), survival to discharge ($p=0.046$), and good neurological outcome ($p=0.265$).

In the final model (Table 4), intermediate STI was significantly associated with good neurological outcome (AOR=1.32, 95% CI;1.03-1.71), while long STI was not (AOR=0.92, 95% CI;0.68-1.26), compared with short STI. Survival to discharge was significantly lower in long STI than in short STI (AOR=0.64, 95% CI;0.52-0.80), but not different in intermediate STI (AOR=0.88, 95% CI=0.74-1.05). Prehospital ROSC was significantly greater both in the intermediate STI group (AOR=2.78, 95% CI;2.18-3.54) and long STI group (AOR=4.23, 95% CI;3.26-5.49) compared to the short STI group. Survival to admission was not significantly associated with the STI groups.

Table 5 shows the summation of effect of STI and interactive effect modifiers on outcomes. AmongOHCA patients who did not receive the bystander defibrillation,the a djusted ORs with 95% CIs for good neurological outcome was significantly higher in the intermediate STI group (AOR 1.40, 95% CI=1.08-1.82), but not different in long STI (AOR 1.01, 95% CI=0.74-1.39). However, either intermediate orlong STI group w as associated with worse neurological outcomeamong patients who received bystander defibrillation; AOR 0.20, 95% CI (0.05-0.92) in intermediate STI and AOR 0.09, 95% CI (0.02-0.44) in long STI group. Both intermediate and long STI were significantly associated with higher prehospital ROSC among patients who did not receive bystande r defibrillation; AOR 2.94, 95% CI (2.29-3.78) in intermediate STI, AOR 4.58, 95% CI (3.50-5.98) in long STI group, respectively. The prehospital ROSC was significantl y lower in the long STI group (AOR 0.24, 95% CI 0.06-0.98), but not in the interm ediate STI group (AOR 0.33, 95% CI 0.09-1.21) among patients who received bystander defibrillation. There was no effect modifier on survival to discharge and to admission.

4. Discussion

By use of data from two large population-based registriesof OHCA in metropolitan cities, we successfully demonstratedthe benefit of EMS activities during intermediate STI from 8 to 16 min forimproving neurological outcome after OHCA.

In Osaka,the OHCA registry was startedin 1998 based on the international guideline for reporting outcomes after OHCA (Utstein Osaka Project).[14,15]In Seoul,a similar OHCA registry was started in 2006,[13,16] and both registriesremain on-going. Recently, in Asia, the attemptto developan international registry of OHCA based on the Utstein style across countries is proceeding.[17]This international collaboration makes it possible to gatherthe large number of standardized data from two largeareassuch as this with different EMS systems,in order to evaluate these important issues.

These data suggest that EMS personnel should perform CPR on the scene at least 8 to 16 minutes before transport to the ED even in the intermediate EMS level where the ALS measurements are limited. The best STI should depend on many factors including EMS levels, the ALS measures the EMS personnel can provide, hospital levels, and EMS response times.

There are many differences in the EMS systems between Osaka and Seoul. Less than 10% of Seoul EMS providers inserted advanced airways, whereas Osaka providers usually selected more than 70% for advanced airways. This discrepancy wouldarise from the different CPR protocolsemployed in each area. Seoul EMS encourages EMS providers to give CPR with/without shock delivery if indicated and to run as soon as possible, while Osaka EMSs encourage providers to run after providing ALS measures including airway, fluid resuscitation, and CPR with/without shock delivery. As a result, Seoul showed very short STI (mean 6.8, standard deviation4.2 min) while Osaka had a longer STI (mean 14.5, standard deviation 6.5 min). The longer STI in Osaka might be one of the reasons for the better outcome of Osaka than Seoul observed in this study. Improving neurological outcome in the intermediate STI group shown in this study covering two different areas suggests that this resultshowing the importance of EMS activities on the scene during early phase of cardiac arrest is robust across different EMS systems.

We assume that the lower quality of CPR during ambulance transport might be one of the possible explanations for thepoorest outcome in the short STI group. It is well known that the quality of CPR is the key to improve outcomes after cardiac arrests.[18,19]CPR during ambulance transport is difficult and tended to show incorrect hand position, insufficient depth, and was interrupted.[18-20]Short STI and low-quality CPR during ambulance transport would result in lower chance of ROSC in the early phase of cardiac arrest and worse neurologic outcome. Longer stay gives a chance to perform higher quality CPR and critical procedures duringthe very critical time window compared to earlier departure for ED.

In intermediate service level EMS, hospital level performance is strongly associated with survival.[21,22]Earlier intervention of advance life support measures would be beneficial in those who do not respond to treatments by EMS providers. In this study, we found the positive association between longer STI and prehospital ROSC as well as good neurological outcome. Longer CPR at the scene would be beneficial for achieving ROSC at the scene as well as final better neurological outcome. Although hospital care options were not adjusted in this study, a significant association between longer STI and ROSC before hospital arrival supportsthe idea that the longer stay and giving CPR are very important determinant in the EMS “Scoop and Run model.”

We found that bystander defibrillation was a strong effect modifier of STI on good neurological outcome and preshopital ROSC. If the patient did not receive bystander defibrillation, intermediate STI was associated with good nuerological outcomewhile both the intermediate and logh STI groupswere associated with worse outcome among patients who received bystander defibrillation. Thses findings would be supported by the three phase model of CPR (1. electrical phase, from the time of cardiac arrest to approximately 4 minutes following the arrest; 2. circulatory phase, from approximately 4 to 10 minutes after cardiac arrest; 3. metabolic phase, extending beyond approximately 10 minutes after cardiac arrest).[23] When OHCA patient does not receive any defibrillation by bystanders, the intermediate STI which means longer CPR time by the EMS personnel at the scene would have benefit because the patient is not under the electrical phase. On the other hand,among patients who has shosckable rhythm and consequently receive the bystander defibrillation in the early electrical phase, the benefit of longer STI would be disappeared. These findings can be considered for developing CPR protocol in scoop and run EMS model.

Different from our “Scoop and Run” model, which has been argued as better for safety as well as quality of CPR[24,25] and widely introduced in many Asian countries, most systems in North America and European EMS allow EMS providers to go on CPR until archiving ROSC or CPR termination under medical oversight unless there is a response. The best timing for stopping CPR on the scene and starting transport to the ED should be different in a “Stayand Treat Model” where EMS providers can provide more ALS measures. However, there still should be additional advanced treatments that can only be provided after hospital arrival;moreover, some studies showed the effectiveness of these treatments.[26,27]In addition, recently, a large observational study of in-hospital cardiac arrest reported that the duration of resuscitation attempts varied between hospitals and suggested that the timing of termination of resuscitation might be too short and thatefforts to systematically increase the duration of resuscitation could improve survival after cardiac arrests.[28]The appropriate STI should be also discussed in this type of EMS system.

Although we found STIeffective for good neurological outcome after OHCAin this study, the appropriate CPR protocolduring this phase is unclear. Theoretically, the short STI from 0 to 7 min would give a chance for four cycles of CPR and rhythm analysis, and median STI from 8 to 15 min would give four more cycles of CPR and rhythm analysis based on the current CPR guideline.[10]STI of 8 to 16 min is not tooshort to allowEMS resuscitation includingCPR, shocks, and some advanced treatments at the scene for OHCA victims. In Arizona, more simplified and compression highlighted CPR protocol was encouraged for EMS providers to provide continuous high-quality CPR at least 8 min without any procedures to interrupt the CPR continuity,and its effectiveness was reported.[29,30]A CPR protocol for EMS providers to provide high-quality CPR during resuscitation on the scene should also be established.

This study has some limitations. First, it is not a randomized controlled trial on the effectsof scene time intervals on OHCA outcomes. Although we adjusted for potential risk confounders, it was limited. The second limitation derives from the study setting. This study was conducted at anintermediate service level at which EMS providers should run to ED while giving CPR during ambulance transport unless there is any ROSC. The study results have limitation to be generalized. The third drawback is that we did not directly measure the treatment options during the scene stay. We just regarded the scene time interval as a treatment time including giving CPR, airway management, shock delivery, and intravenous fluid resuscitation. However, the scene time also include the time usage for failed intubation and reattempts, technical errors, not to mention the time searching for the patient. Therefore, the scene time interval does not always mean actualtreatment time at the scene. Fourth, we did not measure the CPR quality directly, for example, compression depth, CPR fraction, CPR interruption for any procedure. These items are really of crucial importance to improve the outcomes of OHCA. A final limitation should be pointed out. Post-resuscitation care procedures including therapeutic hypothermia and cardiac intervention have been proved very critical interventions for survived patients after OHCA for good neurologic outcome as well as survival to discharge.[31]The two cities had very different hospital care systems. Seoul had one level-1 and 27 level-2 EDs and Osaka had 13 level-1 critical care centers. However, service level, capacity, procedure, and protocol in two cities were neither standardized and nor measured in this study. Therefore, we could not adjust for the hospital level, capacity, and post-resuscitation care procedures. These incomplete adjustments might cause bias for study results.

5. Conclusion

Based on a large population-based cohort covering two metropolitan cities, we found apositive association between intermediate STI from 8 to 16 minutes and good neurological outcome after OHCA. A better EMS resuscitation protocolshould be developed considering this important resuscitation time period on the scene.

Conflict of interest

There are no conflicts of interest to declare.

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Legend to Figures

Fig. 1. Patient enrollment flow in both study sites.

Finally, 7,759 patients (3,594 from Seoul and 4,163 from Osaka) were enrolled in this study.

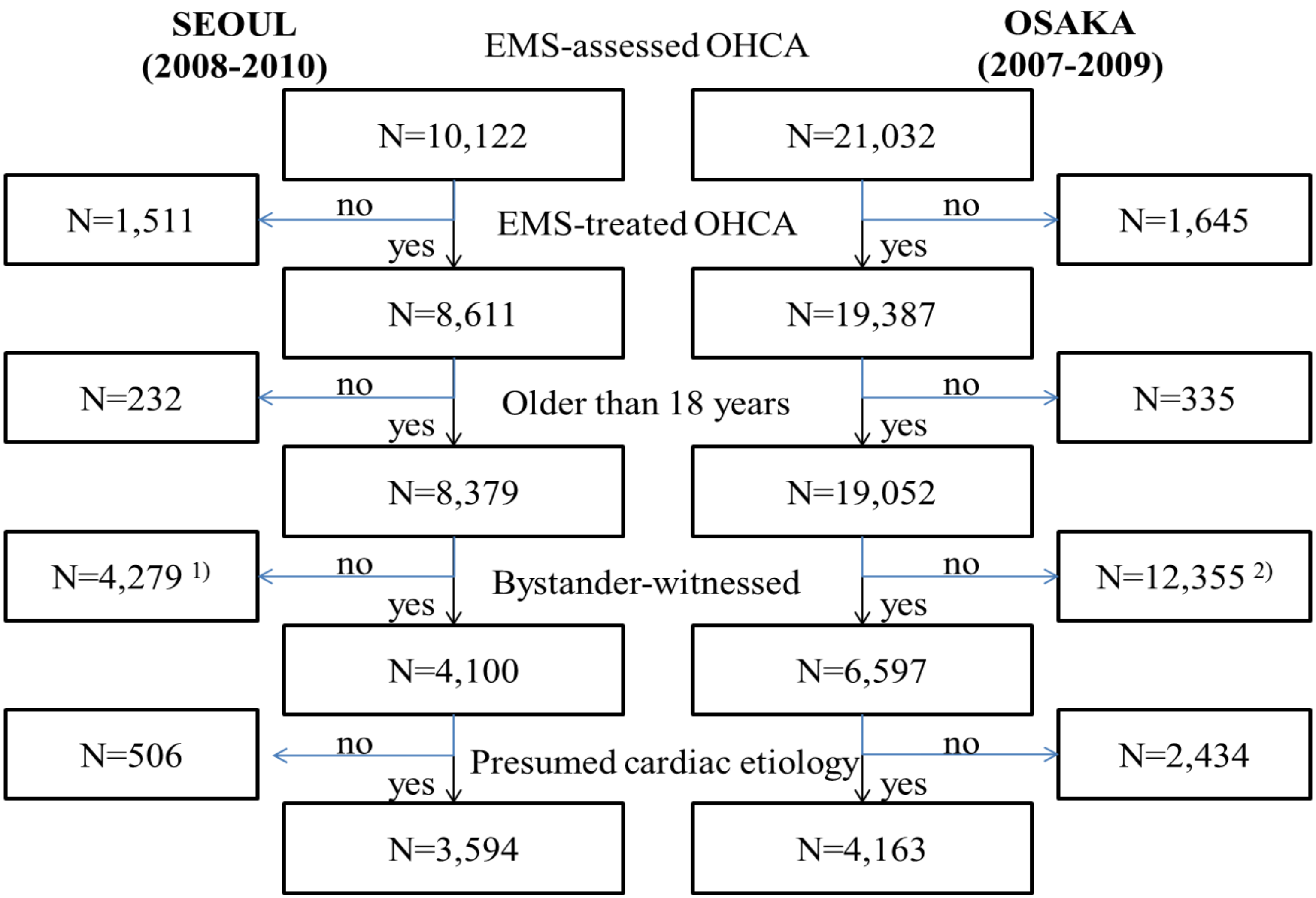
EMS, emergency medical service; OHCA, out-of-hospital cardiac arrest.

Fig. 2. Estimated probability and 95% confidence intervals of survival with good neurological outcome as a function of the STI using 5-knots restricted cubic spline univariatelogistic regression model.

The dark solid line indicates the average probability of survival with good neurological outcome.The red dot lines are cut-off values corresponding to average probability.

STI, scene time interval

Figure 1



1) 338 witnessed by EMS provider and 3,941 not witnessed by lay person
2) 1,482 witnessed by EMS provider and 10,973 not witnessed by lay person

Figure 2

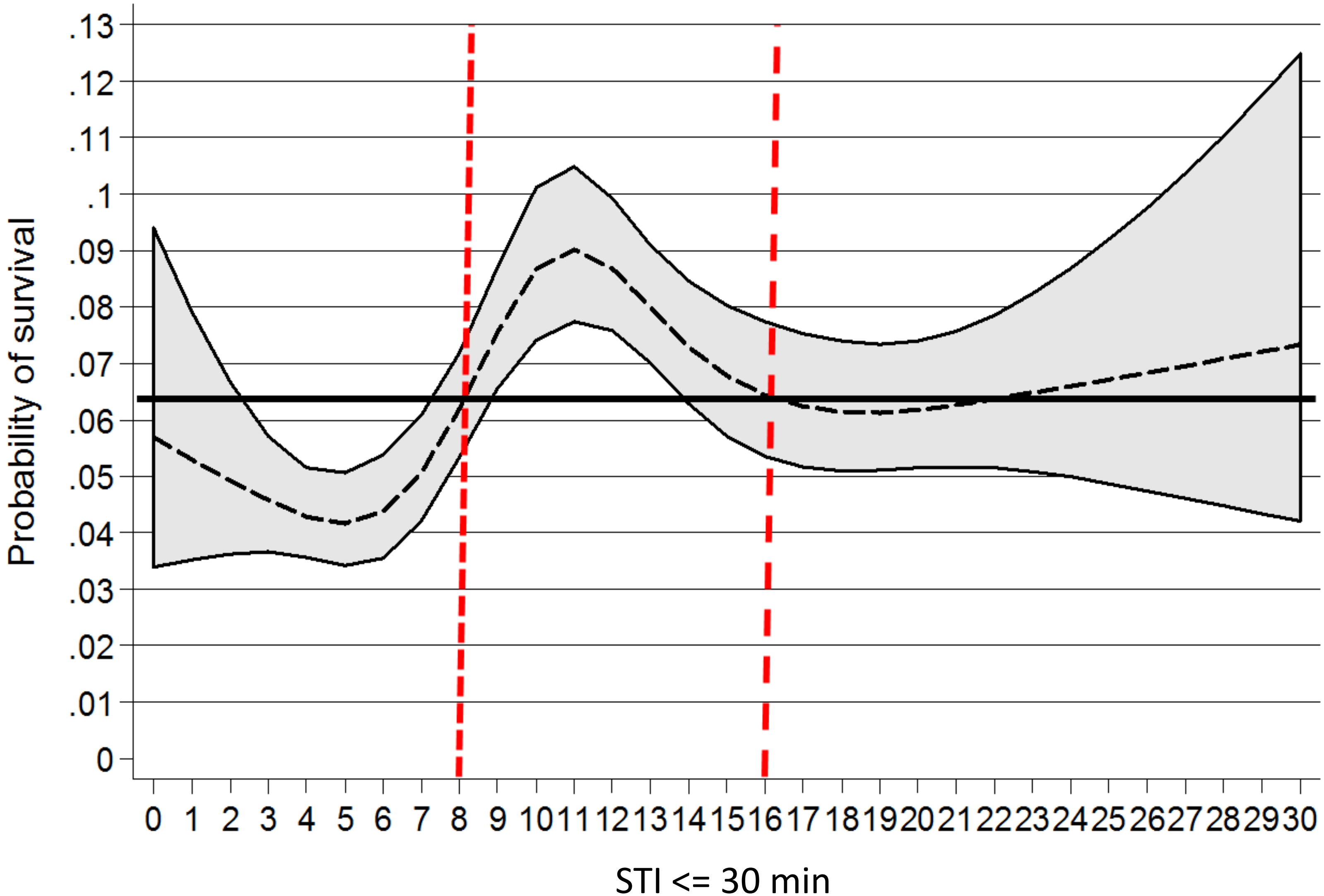

Probability of survival
.13
.12
.11
.1
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
STI <= 30 min

Table 1

Seoul and Osaka demographic findings.

	Total		Seoul		Osaka		*p*
Number of cases, *n* , %	7,757	100.0	3,594	100.0	4,163	100.0	
Year, *n* , %							
2007	1,317	17.0	0	0.0	1,317	31.6	NA
2008	2,508	32.3	1,108	30.8	1,400	33.6	
2009	2,645	34.1	1,199	33.4	1,446	34.7	
2010	1,287	16.6	1,287	35.8	0	0.0	
Female, gender, n, %	2,713	35.0	1,156	32.2	1,557	37.4	<0.001
Age, mean, SD	68.7	16.0	64.8	15.6	72.5	15.3	<0.001
Age group, *n* , %							
10-19 years	17	0.2	10	0.3	7	0.2	<0.001
20-29 years	126	1.6	77	2.1	49	1.2	
30-39 years	263	3.4	173	4.8	90	2.2	
40-49 years	600	7.7	397	11.0	203	4.9	
50-59 years	1,041	13.4	636	17.7	405	9.7	
60-69 years	1,606	20.7	808	22.5	798	19.2	
70-79 years	1,932	24.9	860	23.9	1,072	25.8	
Older than 80 years	2,172	28.0	633	17.6	1,539	37.0	
Public place, *n* , %	2,001	25.8	677	18.8	1,324	31.8	<0.001
Bystander CPR, *n* , %	2,004	25.8	257	7.2	1,747	42.0	<0.001
Bystander defibrillation, *n* , %	89	1.1	0	0.0	89	2.1	<0.001
EMS defibrillation, *n* , %	1,703	22.0	515	14.3	1,188	28.5	<0.001
Primary ECG, *n* , %							
VF/pulseless VT	1,293	16.7	352	9.8	941	22.6	<0.001
PEA	1,742	22.5	358	10.0	1,384	33.2	
Asystole	4,704	60.6	2,878	80.1	1,826	43.9	
Unknown	18	0.2	6	0.2	12	0.3	
Elapsed time intervals, mean, SD							
Response time interval	7.3	3.1	7.0	3.4	7.5	2.8	<0.001
Scene time interval	10.9	6.8	6.8	4.2	14.5	6.5	<0.001
Transportation time interval	7.3	5.1	7.3	5.1	7.2	5.1	0.375
Prehospital time interval	25.4	9.8	21.2	7.9	29.0	9.8	<0.001
Outcomes, *n* , %							
Prehospital ROSC	755	9.7	110	3.1	645	15.5	<0.001
Survival to admission	2,608	33.6	1,033	28.7	1,575	37.8	<0.001
Survival to discharge	1,008	13.0	400	11.1	608	14.6	<0.001
Good neurological outcome	496	6.4	127	3.5	369	8.9	<0.001

CPR, cardiopulmonary resuscitation; EMS, emergency medical service; ECG, electrocardiography; ROSC, return of spontaneous circulation; SD, standard deviation; VF, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity.

Table 2

Distribution of risk factors and outcomes by scene time intervals.

	Total		Short (0=<STI<8)		Intermediate (8=<STI<16)		Long (16=<STI)		*p*
Total, N, %	7,757	100.0	2,739	100.0	3,314	100.0	1,704	100.0	
Year, N, %									
2007	1,317	17.0	135	4.9	712	21.5	470	27.6	<0.001
2008	2,508	32.3	840	30.7	1,064	32.1	604	35.4	
2009	2,645	34.1	919	33.6	1,138	34.3	588	34.5	
2010	1,287	16.6	845	30.9	400	12.1	42	2.5	
City, N, %									<0.001
Seoul	3,594	46.3	2,353	85.9	1,119	33.8	122	7.2	
Osaka	4,163	53.7	386	14.1	2,195	66.2	1,582	92.8	
Gender, N, %									
Male	5,044	65.0	1,866	68.1	2,086	62.9	1,092	64.1	
Female	2,713	35.0	873	31.9	1,228	37.1	612	35.9	
Age group, mean, SD	68.7	16.0	65.1	16.0	70.0	15.6	72.1	15.5	<0.001
Age<65 years	2,741	35.3	1,217	44.4	1,075	32.4	449	26.3	
Age>=65 years	5,016	64.7	1,522	55.6	2,239	67.6	1,255	73.7	
Place of arrest, N, %									<0.001
Public	2,001	25.8	726	26.5	877	26.5	398	23.4	
Private	5,333	68.8	1,807	66.0	2,262	68.3	1,264	74.2	
Unknown	423	5.5	206	7.5	175	5.3	42	2.5	
Bystander CPR, N, %									<0.001
No	5,753	74.2	2,409	88.0	2,279	68.8	1,065	62.5	
Yes	2,004	25.8	330	12.0	1,035	31.2	639	37.5	
Bystander defibrillation, N, %									<0.001
No	7,668	98.9	2,726	99.5	3,265	98.5	1,677	98.4	
Yes	89	1.1	13	0.5	49	1.5	27	1.6	
EMS defibrillation, N, %									<0.001
No	6,054	78.0	2,301	84.0	2,520	76.0	1,233	72.4	
Yes	1,703	22.0	438	16.0	794	24.0	471	27.6	
Primary ECG, N, %									<0.001
VF/pulseless VT	1,293	16.7	342	12.5	601	18.1	350	20.5	
PEA	1,742	22.5	381	13.9	810	24.4	551	32.3	
Asystole	4,722	60.9	2,016	73.6	1,903	57.4	803	47.1	
Unknown	18	0.2	8	0.3	4	0.1	6	0.4	
Elapsed time intervals, N, %									
Response time, mean, SD	7.3	3.1	7.0	3.1	7.4	2.8	7.6	3.5	<0.001
Transportation time interval, mean, SD	7.3	5.1	7.1	5.1	7.2	4.9	7.9	5.4	<0.001
Prehospital time, mean, SD	25.4	9.8	18.7	6.5	25.7	6.5	35.5	10.5	<0.001

STI, scene time interval from ambulance wheel arrival to departure (unit: minute.); CPR, cardiopulmonary resuscitation; EMS, emergency medical service; ECG, electrocardiography; ROSC, return of spontaneous circulation; SD, standard deviation; VF, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity.

Table 3

Outcomes after OHCA by scene time interval group and city.

City	Outcome	Total		Short 0<=STI<8 min		Intermediate 8<=STI<16 min		Long 16<=STI min		*P*
		N	%	N	%	N	%	N	%	
Total	Total	7,757		2,739		3,314		1,704		
	Preshospital ROSC	755	9.7	97	3.5	374	11.3	284	16.7	< 0.001
	Survival to admission	2,608	33.6	871	31.8	1,182	35.7	555	32.6	0.004
	Survival to discharge	1,008	13.0	359	13.1	453	13.7	196	11.5	0.094
	Good neurological outcome	496	6.4	127	4.6	256	7.7	113	6.6	< 0.001
Seoul	Total	3,594		2,353		1,119		122		
	Preshospital ROSC	110	3.1	58	2.5	47	4.2	5	4.1	0.017
	Survival to admission	1,033	28.7	704	29.9	303	27.1	26	21.3	0.041
	Survival to discharge	400	11.1	280	11.9	107	9.6	13	10.7	0.121
	Good neurological outcome	127	3.5	83	3.5	40	3.6	4	3.3	0.986
Osaka	Total	4,163		386		2,195		1,582		
	Preshospital ROSC	645	15.5	39	10.1	327	14.9	279	17.6	< 0.001
	Survival to admission	1,575	37.8	167	43.3	879	40.0	529	33.4	< 0.001
	Survival to discharge	608	14.6	79	20.5	346	15.8	183	11.6	< 0.001
	Good neurological outcome	369	8.9	44	11.4	216	9.8	109	6.9	0.001

OHCA, out-of-hospital cardiac arrest; STI, scene time interval; ROSC, return of spontaneous circulation.

Table 4

Association between scene time intervals and outcomes after OHCA.

Outcomes	Total	Outcome		Crude OR			Adjusted OR		
Scene time interval	N	N	%	OR	95% CI		OR	95% CI	
Prehospital ROSC, total	7,757	755	9.7						
0=<STI<8 min	2,739	97	3.5	Reference			Reference		
8=<STI<16 min	3,314	374	11.3	3.47	2.76	4.36	2.78	2.18	3.54
16=< STI min	1,704	284	16.7	5.45	4.29	6.92	4.23	3.26	5.49
Survival to admission, total	7,757	2,608	33.6						
0=<STI<8 min	2,739	871	31.8	Reference			Reference		
8=<STI<16 min	3,314	1,182	35.7	1.19	1.07	1.32	1.10	0.98	1.24
16=< STI min	1,704	555	32.6	1.04	0.91	1.18	0.94	0.82	1.09
Survival to discharge, total	7,757	1,008	13						
0=<STI<8 min	2,739	359	13.1	Reference			Reference		
8=<STI<16 min	3,314	453	13.7	1.05	0.91	1.22	0.88	0.74	1.05
16=< STI min	1,704	196	11.5	0.86	0.72	1.04	0.64	0.52	0.80
Good neurological outcome, total	7,757	496	6.4						
0=<STI<8 min	2,739	127	4.6	Reference			Reference		
8=<STI<16 min	3,314	256	7.7	1.72	1.38	2.14	1.32	1.03	1.71
16=< STI min	1,704	113	6.6	1.46	1.13	1.90	0.92	0.68	1.26

ROSC, return of spontaneous circulation; STI, scene time interval from wheel arrival to departure; OR, odds ratio; CI, confidence interval.

Adjusted ORs were caluculated by adjusting for city, age, gender, response time interval, transportation time interval, place, bystander cardiopulmonary resuscitation, defibrillation by lay person, defibrillation by emergency medical service (EMS) providers, and primary ECG rhythm in the model.

Table 5

Association between scene time interval and outcomes considering the effect of interaction terms.

Outcomes	Effect modifier	Scene time interval						
		<8 min	8-16 min			>= 16 min		
Good neurological outcome			AOR	95% CI		AOR	95% CI	
	Bystander defibrillation							
	No	Reference	1.40	1.08	1.82	1.01	0.74	1.39
	Yes	Reference	0.20	0.05	0.92	0.09	0.02	0.44
Prehospital ROSC								
	Bystander defibrillation							
	No	Reference	2.94	2.29	3.78	4.58	3.50	5.98
	Yes	Reference	0.33	0.09	1.21	0.24	0.06	0.98

ROSC, return of spontaneous circulation; AOR, adjusted odds ratio; CI, confidence interval.

AORs were caluculated by constrast estimate for all corresponding interaction variables adjusting for potential confounders in the final model.